July 15, 1990 Volume 197 Number 2

JOURNAL

OF THE AMERICAN VETERINARY MEDICAL ASSOCIATION

Julie and Her Friends, 1981

James Harvey Johnson, DVM

JOURNAL
OF THE AMERICAN VETERINARY MEDICAL ASSOCIATION

© American Veterinary Medical Association, 1990
All Rights Reserved

Vol 197 July 15, 1990 No. 2
JAVMA 197 (2) 161-288 (1990)
ISSN 0003-1488

Interpretive Summaries of Articles in This Issue 164

Letters

Clarification of iodine lavage solution for treatment of peritonitis 168
Recognizing professional ethics as a useful discipline 168
Questions about ECG interpretations 169

News

Out and About—Postgraduate program repositions veterinarians in swine industry 173
Veterinary team runs Boston Marathon for Heifer Project 175
Under the Umbrella 176
AVMA at Work—Judicial Council meets 177
Student and School Scenes—Iowa State hosts US-Soviet symposium 179
Coast to Coast 180
Regulatory Front—"Teaching" hospitals qualify for DEA facility registration 181
Food Safety Update—FSIS schedules hazard analysis hearings 182

Food for thought for food animal veterinarians

The need for graduates in food animal medicine—*John B. Herrick* 183

Special Report

Emergency treatments for police dogs used for illicit drug detection—*Genevieve A. Dumonceaux and Val Richard Beasley* 185

Food Animal Economics

Economic analysis of an epizootic of pseudorabies and subsequent production following the institution of a vaccination program in a Pennsylvania swine herd—*T. D. Parsons, P. M. Pitcher, and C. Johnstone* 188

Special Commentary

Pet population control: Another decade without solutions?—*Craig N. Carter* 192

The *Human* Side of Veterinary Medicine

Answering clients' difficult questions
Jacob Antelyes 197

Reports of Original Studies

Epidemiologic factors, clinical findings, and vaccination status of rabies in cats and dogs in the United States in 1988—*Thomas R. Eng, Daniel B. Fishbein, and the National Study Group on Rabies* 201

Fecal proteolytic activity in clinically normal cats and in a cat with exocrine pancreatic insufficiency—*David A. Williams, Scott D. Reed, and Lindall Perry* 210

Effect of chewing rawhide and cereal biscuit on removal of dental calculus in dogs
Arthur Lage, Niels Lausen, Ronald Tracy, and Elizabeth Allred 213

Epizootiologic association between feline immunodeficiency virus infection and feline leukemia virus seropositivity—*N. D. Cohen, C. N. Carter, M. A. Thomas, T. L. Lester, and A. K. Eugster* 220

Clinical Reports

Osteogenic sarcoma and myasthenia gravis in a dog—*A. S. Moore, B. R. Madewell, G. H. Cardinet III, and G. D. Shelton* 226

Peripheral hypomyelinization in two Golden Retriever littermates—*Michael E. Matz, Linda Shell, and Kyle Braund* 228

Generalized lymphangiectasis in a dog with subcutaneous chyle and lymphangioma
Theresa W. Fossum, Carlos C. Hodges, Daniel W. Scruggs, and Robert A. Fiske 231

Persistent hematuria in a dog with renal hemangioma—*William R. Widmer and William W. Carlton* 237

Chordoma in a cat—*James L. Carpenter, Barbara S. Stein, Norval W. King, Yogeshwar D. Dayal, and Frances M. Moore* 240

Hepatic myelolipomas in a cat
Dudley L. McCaw, Jeannette M. A. da Silva Curiel, and Daniel P. Shaw 243

Reports of Retrospective Studies

Cerebrospinal fluid creatine kinase activity in horses with central nervous system disease: 69 cases (1984-1989)—*Martin O. Furr and Ronald D. Tyler* 245
Obstructive nephrolithiasis and ureterolithiasis associated with chronic renal failure in horses: Eight cases (1981-1987)—*S. J. Ehnen, T. J. Divers, D. Gilette, and V. B. Reef* 249

Review Article

Economic relevance, diagnosis, and countermeasures for degenerative joint disease (osteoarthrosis) and dyschondroplasia (osteochondrosis) in pigs
Michael A. Hill 254

What Is Your Diagnosis?

Sophia Avgeris and Gregory Daniel 261

Book Review

The Equine Acute Abdomen 248

Abstracts of Selected Reports

Evaluation of biochemical evidence of congenital nutritional myopathy in two-week prepartum fetuses from selenium-deficient ewes 225
Mast cell tumor destruction by deionized water 236

Announcements

Coming Meetings 263
Foreign Meetings 265
Educational Opportunities 266
Certification Examinations 267
State Board Examinations 267
Applications for Membership 267

Classified Ads

. 269

Correction

Drug therapy in cats: A therapeutic category approach—*Dawn Merton Boothe* 242

Cover artist

Dr. James Harvey Johnson is a veterinary clinical associate in the Department of Veterinary Physiology and Pharmacology at the Texas A&M University College of Veterinary Medicine.

The covers of the mid-month issues of the JAVMA feature animal artwork created by people associated with the veterinary profession (ie, veterinarians and members of their family or staff, veterinary educators, and veterinary students). Those wishing to have their artwork considered for reproduction on the cover of the JAVMA should submit color photographs (identified with the artist's name and relationship to the veterinary profession, address, and daytime telephone number) to Dr. Janis H. Audin, AVMA, 930 N Meacham Rd, Schaumburg, IL 60196.

Coming Soon . . .

August 1

Research Roundup—Diagnosis of paratuberculosis (P. M. Sanftleben)

Statistics Simplified—*P* Values (C. R. Curtis et al)

Legal Brief—Human injury by animals other than dogs and cats—the veterinarians's involvement (H. W. Hannah)

Career Pathways in Veterinary Medicine—Relief Veterinarian: A flexible alternative (D. H. D'Orazio)

Special commentary—Specialization in veterinary medicine: Where we've been and where we're going (J. F. Fessler et al)

August 15

Special Commentary—Endotoxin as an alarm signal of bacterial invasion: Current evidence and implications (E. K. LeGrand)

Letter—Clarification of reporting requirements for Animal Welfare Act

Ovine progressive pneumonia: Prevalence and effect of subclinical virus infection on ewe wool and lamb production (G. D. Snowder et al)

Efficacy of intramammary treatment in unbred and primigravid dairy heifers (P. Trinidad et al)

An epizootic of peroneal and tibial neuropathy in Walker Hound pups (H. E. Jans et al)

Changes in blood gas and acid-base values of bovine venous blood during storage (O. Szenci and T. Besser)

Epidemiologic factors, clinical findings, and vaccination status of rabies in cats and dogs in the United States in 1988

Thomas R. Eng, VMD, MPH; Daniel B. Fishbein, MD; the National Study Group on Rabies

Summary: *Despite the availability of rabies vaccination through private veterinarians and government-sponsored rabies control programs, rabies was reported in an average of 338 cats and dogs per year from 1980 through 1987 in the United States. Information was collected on 90% of the 183 cats and 97% of the 119 dogs that were reported to have rabies in the continental United States in 1988. The median age of rabid cats and dogs was 1 year, and 81% were from rural areas. Compared with rabid cats, rabid dogs were more likely to have been male (66 vs 42%, odds ratio = 2.6), to have been kept as pets (84 vs 43%, odds ratio = 6.8), and to have had reported contact with wildlife before onset of illness (38 vs 14%, odds ratio = 3.8). Rabid cats accounted for a greater proportion of human rabies postexposure prophylaxis, bites to people, and exposures to other animals than did rabid dogs. Although the clinical signs of rabies varied, rabid cats were more likely than dogs to have had aggressive behavior (55 vs 31%, odds ratio = 2.8). In contrast, rabid dogs were more likely than cats to have had an illness consistent with a paralytic process. The median period between onset of illness and death was 3 days (range, < 1 to 10) in rabid cats and dogs that were allowed to die of rabies. Vaccine failures were documented in 3 (1%) rabid animals (2 cats and 1 dog). All animals had received only a single dose of vaccine in their lifetime and were vaccinated when they were between 3 and 6 months old.*

Although the most recent human case of rabies attributable to a rabid cat or dog in the United States was reported in 1979,[1] an average of 338 cases of rabies in cats and dogs was reported annually from 1980 through 1987.[2] Approximately half[3] of the estimated 18,000 persons that receive rabies postexposure prophylaxis every year do so because of exposure to rabid cats and dogs.

The most recent epidemiologic studies of rabid cats or dogs in the United States described cases reported from 1971 through 1973 and from 1980

From the Division of Viral and Rickettsial Diseases, Center for Infectious Diseases, Centers for Disease Control, US Department of Health and Human Services, 1600 Clifton Rd NE, Atlanta, GA 30333 (Eng, Fishbein). Dr. Eng's present address is Office of Medical Services, Peace Corps, 1990 K St NW, Washington, DC 20526.

The authors thank the late Dr. Richard L. Parker, Drs. William G. Winkler and George M. Baer, and John O'Connor for technical assistance.

Send reprint requests to Dr. Fishbein, Viral and Rickettsial Zoonoses Branch, Centers for Disease Control, 1600 Clifton Rd, Mailstop G13, Atlanta, GA 30333.

Presented in part at the 126th annual meeting of the American Veterinary Medical Association in Orlando, Fla, July 1989.

Members of the National Study Group on Rabies include: Pam J. Archer, MPH, Oklahoma Department of Health; Larry Barrett, MS, DVM, California Department of Health Services; Richard Circo, MS, Wisconsin State Laboratory of Hygiene; Keith Clark, DVM, PhD, Texas Department of Health; Lisa Conti, DVM, Florida Department of Health and Rehabilitative Services; Russell W. Currier, DVM, MPH, Iowa Department of Public Health; James Dobbins, PhD, Centers for Disease Control (CDC); John M. Doll, PhD, Arizona Department of Health Services; Marguerite Edelmann, Arkansas Department of Health; Millicent Eidson, MA, DVM, New Mexico Department of Health and Environment; Keith A. Friendshuh, DVM, Minnesota Board of Animal Health; Thomas T. Gilbert, MD, MPH, CDC; Martha Greco, DVM, MPH, Maryland Department of Public Health and Mental Hygiene; Loretta E. Haddy, MA, MS, West Virginia Department of Health; Kristina Harper, Washington DC Department of Human Services; Fred F. Heer, North Dakota Department of Health; Lee Hunter, DVM, North Carolina Department of Human Resources; D. Owen James, DVM, Montana Department of Livestock; Suzanne R. Jenkins, VMD, MPH, Virginia Department of Health; Bobby R. Jones, DVM, MPH, Pennsylvania Department of Health; Jeffrey L. Jones, MD, MPH, CDC; Mike Marshall, DVM, Utah Department of Agriculture; Louise McFarland, DrPH, Louisiana Department of Health and Human Resources; John W. Mermott, PhD, Michigan Department of Public Health; Roger F. Murray, MA, Nebraska Department of Health; John Pape, Colorado Department of Health; Donald G. Ritter, Alaska Department of Health and Social Services; F. T. Satalowich, DVM, MSPH, Missouri Department of Health; Linda Schaefer, South Dakota Department of Health; James M. Shuler, DVM, MPH, Indiana Board of Health; Joseph W. Skaggs, DVM, MPH, Kentucky Department for Health Services; Kathleen A. Smith, DVM, Ohio Department of Health; Faye Sorhage, VMD, MPH, New Jersey Department of Health; Gary L. Swinger, DVM, Tennessee Department of Health and Environment; Carol F. Teplis, University of Georgia College of Veterinary Medicine; Mary Kay Tinker, Virginia-Maryland College of Veterinary Medicine; Susan C. Trock, DVM, CDC; Evelyn H. Weir, Georgia Department of Human Resources; David E. Wolfe, RN, MPH, Delaware Department of Health and Social Services; and Lynn F. Woodard, DVM, PhD, Wyoming State Veterinary Laboratory.

through 1983.[4,5] However, in both of these studies, a standardized questionnaire was not used to interview the owners of rabid animals, some information was not collected in a timely manner, and case investigations were not always complete.

Systematically collected clinical information on rabies in naturally infected animals in the United States has been limited. In experimental infections, approximately 69% and 37% of rabid cats and dogs, respectively, have aggressive behavior.[6,7]

Although vaccine manufacturers are required to test the potency of rabies vaccines before release, a formal surveillance system for rabies vaccine failures in animals does not exist, and it is unclear how well rabies vaccines perform in the field. In 1988, 24 rabies vaccines were approved by the USDA for use in cats or dogs or both.[8] The USDA requires that licensed vaccines protect at least 86% of vaccinated laboratory dogs or cats and that at least 80% of unvaccinated controls die after inoculation with live rabies virus.[9]

The purpose of the study reported here was to compare the epidemiologic factors, clinical findings, and incidence of vaccine failures in rabid cats and dogs in 1988.

Methods

In 1987, all state health departments that had reported at least one rabid cat or dog to the Centers for Disease Control (CDC) in the preceding 3-year period were contacted. Each state was asked to prospectively provide information on all laboratory-confirmed cases of rabies in cats and dogs diagnosed between Jan 1 and Dec 31, 1988. A laboratory-confirmed case was defined as one involving an animal with a positive direct fluorescent antibody test result of brain tissue or rabies virus isolation in mice or in tissue culture. After laboratory confirmation, personnel from local or state departments of health or agriculture used a standardized questionnaire to interview the owners of rabid animals. When owners could not be identified, the person who submitted the animal for testing was interviewed. If a veterinarian examined the animal, he or she was also interviewed. Almost all questionnaires were completed several days to a few weeks after laboratory diagnosis. The questionnaire elicited information on demographics, clinical signs of rabies, rabies vaccination history, potential risk factors for rabies, and rabies postexposure prophylaxis for persons associated with each animal. A true exposure to rabies was defined as either a bite from a rabid animal or contamination of an open wound or mucous membrane with saliva from a rabid animal. Observed contact with another animal was defined as the respondent having observed the cat or dog playing or fighting with another animal. An unrestrained animal was defined as one that was not confined indoors or physically restrained either in a pen or on a leash. An unexplained lameness or wound was defined as a lameness or wound for which the owner was not able to give a specific cause. A vaccine failure was defined as a case in which a rabid animal had been vaccinated with a licensed rabies vaccine between 1 and 12 months before onset of illness if a vaccine of 1-year duration was used, or between 1 and 36 months if a vaccine of 3-year duration was used.

After initial data analysis, persons associated with rabid animals that were reported to be without clinical signs of rabies or with animals reported to have had current vaccinations were reinterviewed to confirm and clarify information. All questionnaires were analyzed at CDC.

Data on the geographic and seasonal distribution of rabid cats and dogs were abstracted from the database used to generate the annual rabies surveillance report published by CDC, because this database had these data for all reported cases in 1988.[10]

To examine trends in characteristics of rabid dogs, we compared our data with that reported in the 2 most recent studies of rabid dogs in the United States.[4,5]

Statistical tests used for data analysis included the χ^2 square test, the Wilcoxon rank sum test, and the Cornfield approximation for calculating 95% confidence intervals (CI) for odds ratios (OR).

Results

Epidemiologic factors—In 1988, 183 cases of rabies in cats and 119 cases in dogs were reported in the continental United States. Complete information was obtained on 165 (90%) rabid cats and 115 (97%) rabid dogs. The south Atlantic, north central, south central, and mid-Atlantic states accounted for 90% of all cases in cats (Fig 1). The geographic distribution of rabid dogs was similar, with 84% of cases reported from states in the south central, north central, and south Atlantic regions of the United States. Rabies in cats was most commonly reported from June through October, whereas rabies in dogs appeared to have a bimodal distribution, with most cases diagnosed from March through May and from October through December (Fig 2).

The age distribution of rabid cats and dogs was not statistically different (Wilcoxon rank sum test, $P = 0.12$); the median age of rabid cats (range, < 1 to 11) and dogs (range, < 1 to 14) was 1 year (Table 1). Forty-one percent of animals were < 1 year old and 77% were < 3 years old. Rabid dogs were significantly more likely to be male than were cats (OR = 2.6, 95% CI = 1.5, 4.7). The proportions of neutered rabid cats and dogs were low. Rapid dogs were significantly more likely to have been pets than were cats; 84% of dogs were pets compared with only 43% of cats (OR = 6.8, 95% CI = 3.6, 12.9). A number of animals were not considered as pets or strays but as "barn" or "farm" animals. A higher proportion of dogs were from rural areas, and the distribution of cats and dogs by the type of environment where the animal resided was almost

Figure 1—Geographic distribution of rabid cats (A) and dogs (B) in the United States, 1988.[10]

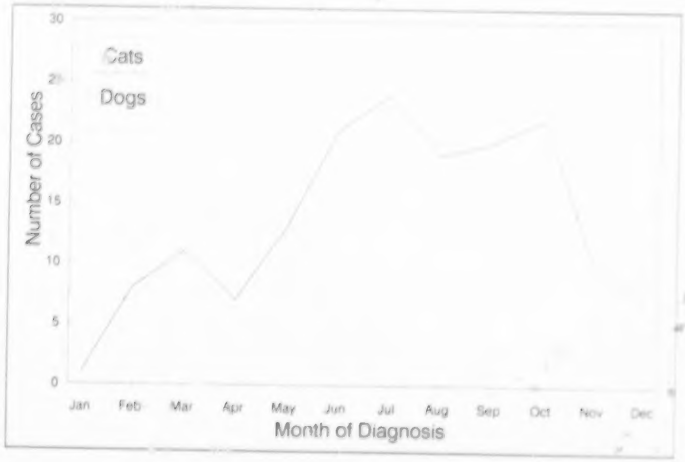

Figure 2—Distribution of rabid cats and dogs by month of diagnosis, 1988.[10]

statistically different ($\chi^2 = 7.34$, 3 df, $P = 0.06$). Only 1% of all cats and dogs confirmed as rabid were found dead on roads. Rabies was confirmed by direct fluorescent antibody testing in (245) rabid cats and dogs and by virus isolation in 4.

In the 6-month period before the onset of illness, owners of rabid dogs (ie, pets and barn animals) were more likely than owners of cats to have observed the animal in contact with a wildlife species susceptible to rabies (38% vs 14%, respectively, OR = 3.8, 95% CI = 1.7, 8.6; Table 2). Skunks accounted for most of the observed contacts with wildlife. A small proportion of animals had contact with a previously confirmed rabid animal.

Most rabid cats and dogs were not restrained

Table 1—Characteristics of rabid cats and dogs

Characteristic	No. (%) of: Cats	Dogs	Total
Age (yr)			
< 1	53 (39)	40 (43)	93 (41)
1	32 (24)	13 (14)	45 (20)
2	25 (19)	12 (13)	37 (16)
3	11 (8)	6 (6)	17 (7)
4	6 (4)	5 (5)	11 (5)
5	5 (4)	3 (3)	8 (3)
> 5	3 (2)	15 (16)	18 (8)
Gender			
Male	50 (42)	67 (66)	117 (53)
Female	68 (58)	35 (34)	103 (47)
Neuter status			
Neutered	6 (5)	6 (7)	12 (6)
Not neutered	106 (95)	85 (93)	191 (94)
Ownership status			
Pet	69 (43)	91 (84)	160 (59)
Stray	73 (45)	11 (10)	84 (31)
"Barn" or "farm"	20 (12)	7 (6)	27 (10)
Type of environment			
Rural	122 (78)	88 (85)	210 (81)
Suburban	27 (17)	7 (7)	34 (13)
Urban	5 (3)	7 (7)	12 (5)
Other	3 (2)	2 (2)	5 (2)
Manner of death			
Euthanatized	136 (86)	83 (74)	219 (81)
Died naturally	22 (14)	26 (23)	48 (18)
Road kill	1 (<1)	3 (3)	4 (1)
Veterinary care			
Yes	74 (46)	79 (72)	153 (57)
No	87 (54)	31 (28)	117 (43)
Vaccination status			
Current	2 (1)	2 (2)	4 (1)
Expired	6 (4)	14 (12)	20 (7)
Never vaccinated	97 (59)	76 (66)	173 (62)
Unknown	60 (36)	23 (20)	83 (30)

Cases for which the information was unknown were not included.

Table 2—Characteristics of owned and stray rabid cats and dogs in the six-month period before onset of illness

Characteristic	No. (%) of: Cats	Dogs	Total
Owned animals			
Reported contact with:			
Skunk	8 (9)	29 (31)	37 (21)
Raccoon	1 (1)	3 (3)	4 (2)
Other wild animal*	3 (4)	4 (4)	7 (3)
Confirmed rabid animal	1 (1)	3 (3)	4 (2)
Unrestrained outdoors	82 (99)	58 (64)	140 (80)
Unrestrained at night	72 (87)	67 (77)	139 (82)
Missing for 24 hours	21 (28)	17 (20)	38 (23)
Unexplained lameness	19 (23)	19 (22)	38 (22)
Unexplained wound	17 (20)	18 (20)	35 (20)
Used for hunting	1 (1)	13 (14)	14 (8)
Foreign travel	0 (0)	2 (2)	2 (1)
Stray animals			
Previously seen	46 (69)	7 (70)	53 (69)
Fed regularly	24 (38)	5 (56)	29 (40)
Wearing collar	2 (3)	0 (0)	2 (2)
Area where captured			
Residential	38 (53)	3 (30)	41 (50)
Agricultural	21 (29)	4 (40)	25 (30)
Recreational	5 (7)	0 (0)	5 (6)
Commercial	2 (3)	2 (20)	4 (5)
Other	6 (8)	1 (10)	7 (9)

*Three cats had contact with 2 wild cats and 1 unidentified wild animal, and 4 dogs had contact with 2 coyotes, 1 bobcat, and 1 groundhog, respectively.
Cases for which the information was unknown were not included.

when outdoors or at night (Table 2). Cats were more likely than dogs to have been unrestrained when outdoors (OR = 46.7, 95% CI = 6.5, 177.6). Similar proportions of cats and dogs were reported missing for at least one 24-hour period, and similar proportions were reported to have had a wound or lameness of unknown cause. Only 2 animals had been exposed outside of the United States, both of which were pups imported from Mexico.[10,11]

Among rabid animals considered to be strays, a large proportion were familiar in the community and many had routine contact with people (Table 2). For example, 69% of stray animals were previously seen in the community and 40% were fed on a regular basis by someone in the community. Few of the stray animals were wearing collars when they were captured and most were captured in residential or agricultural areas.

Human rabies postexposure prophylaxis was given as a result of possible exposure to 86% of rabid cats and 79% of rabid dogs (Table 3). Rabid cats were more likely than dogs to have bitten a person (OR = 2.8, 95% CI = 1.6, 5.0). The proportion of nonbite exposures (ie, scratches or licks on an open wound or mucous membrane) to rabid cats or dogs were similar. There was no significant difference in the proportion of these animals that exposed other animals. At least 795 persons re-

Table 3—Exposures to people and other animals by rabid cats and dogs

Exposures to	Cats	Dogs	Total
People			
No. (%) of rabid animals that			
Resulted in postexposure prophylaxis	137 (86)	85 (79)	222 (83)
Bit a person	93 (62)	35 (36)	128 (52)
Scratched or licked a person	49 (39)	32 (37)	81 (38)
Median No. (range) of persons vaccinated per rabid animal	1 (0 to 18)	2 (0 to 21)	2 (0 to 21)
No. (%) of vaccinated persons that			
Were bitten	146 (33)	48 (13)	194 (24)
Were scratched or licked	169 (39)	196 (55)	365 (46)
Median No. (range) bitten per animal	1 (0 to 13)	0 (0 to 5)	1 (0 to 13)
Median No. (range) scratched or licked	1 (0 to 11)	1 (0 to 21)	1 (0 to 21)
Other Animals			
No. (%) of rabid animals that exposed other animals	89 (68)	54 (66)	143 (67)
Median No. (range) of other animals exposed per rabid animal	2 (0 to 67)	1 (0 to 37)	2 (0 to 67)

Cases for which the information was unknown were not included.

ceived postexposure prophylaxis as a result of exposures to the 267 rabid cats and dogs for which the information was available. Extrapolation of this rate to the 302 reported cases of rabies in cats and dogs in 1988 indicates that approximately 900 persons in the United States received postexposure prophylaxis because of confirmed rabies in cats and dogs. Although contact with each rabid animal usually resulted in the prophylaxis of only 1 or 2 persons, in one case, a single rabid cat exposed 21 persons. Seventy-percent of patients who received postexposure prophylaxis had true exposures to rabies. At least 779 other animals were exposed by rabid cats and dogs. Although one rabid cat exposed at least 67 other farm animals, the number of animals exposed by rabid cats was not significantly different from that of dogs (Wilcoxon rank sum, $P = 0.12$).

Clinical findings—Rabid dogs were more likely to have been taken to a veterinarian for their illness than were rabid cats (OR = 3.0, 95% CI = 1.7, 5.6; Table 2). The initial diagnoses of veterinarians who examined these animals were similar among cats and dogs (Table 4). Although rabies or "possible rabies" were the most common diagnoses, these were considered to be the primary diagnoses by less than half of veterinarians at the time of examination.

Table 4—Initial diagnoses by veterinarians who examined rabid cats and dogs

Diagnosis	No. (%) of		
	Cats	Dogs	Total
Rabies	17 (23)	18 (23)	35 (23)
Possible rabies	16 (22)	18 (23)	34 (22)
CNS disorder	5 (7)	4 (5)	9 (6)
Trauma	5 (7)	1 (1)	6 (4)
Poisoning	1 (1)	4 (5)	5 (3)
Other	9 (12)	12 (15)	21 (14)
None or unknown	21 (28)	22 (28)	43 (28)
Total	74	79	153

Reported signs in rabid animals ranged from fairly specific findings of rabies, such as jaw and limb paralysis, to nonspecific findings such as fever and lethargy (Table 5). Of the 251 animals for which at least one sign was reported, the only sign in most rabid cats or dogs was aggressiveness in cats. Several clinical findings in cats and dogs were significantly different (Table 5). Rabid cats were more likely than rabid dogs to have had aggressive behavior. In contrast, rabid dogs were more likely than rabid cats to have had ataxia, anorexia, lethargy, excessive salivation, dysphagia, limb and jaw paralysis, and fever.

Thirteen (8%) cats and 6 (5%) dogs were reported to be without clinical signs of rabies during their illness. However, of these 19 animals, 9 were stray animals, 6 were pets that were not closely observed during their illness, 2 actually had clinical signs, and 1 was found dead on a road. The owners of the remaining animal were not available for a second interview.

To examine the course of naturally acquired rabies infection, we reviewed the records of the 15 cats and 22 dogs that had been allowed to die of rabies and had a known date of onset. The median interval from onset of signs to the date of death was 3 days in both cats and dogs; all animals except 2 (95%) died within 7 days after onset of illness (Fig 3). One cat, however, died on the tenth day of illness.

Vaccination status—Most rabid cats and dogs were never vaccinated (Table 2). Assuming that animals of unknown vaccination histories were probably never vaccinated, only 5% and 14% of rabid cats and dogs, respectively, had ever been vaccinated. Rabid dogs were more likely to have been vaccinated than were cats (OR = 3.2, 95% CI = 1.2, 8.4). Only 4 (1%) cats and dogs had a current vaccination. Of these, 2 cats and 1 dog were vaccinated at least 1 month before onset of illness and their cases were considered vaccine

Table 5—Clinical findings in rabid cats and dogs

Sign	No. (%) of			OR [95% CI]
	Cats	Dogs	Total	
Aggressiveness	81 (55)	32 (31)	113 (45)	2.8 [1.6, 4.9]*
Ataxia	44 (30)	51 (49)	95 (38)	0.4 [0.3, 0.8]*
Irritability	50 (34)	24 (23)	74 (29)	1.7 [0.9, 3.2]
Anorexia	32 (22)	39 (38)	71 (28)	0.5 [0.3, 0.8]*
Lethargy	29 (20)	38 (37)	67 (27)	0.1 [0.1, 0.3]*
Excess salivation	20 (14)	43 (41)	63 (25)	0.2 [0.1, 0.4]*
Hyperexcitability	38 (26)	21 (20)	59 (24)	1.4 [0.7, 2.6]
Restlessness	34 (23)	25 (24)	59 (24)	1.0 [0.5, 1.8]
Dysphagia	15 (10)	31 (30)	46 (18)	0.3 [0.1, 0.6]*
Lameness	26 (18)	17 (16)	43 (17)	1.1 [0.5, 2.3]
Limb paralysis	25 (17)	30 (29)	55 (16)	0.5 [0.3, 0.96]*
Jaw paralysis	4 (3)	30 (29)	34 (14)	0.1 [0.02, 0.2]*
Change in voice	24 (16)	9 (9)	33 (13)	2.1 [0.9, 5.0]
Hyperesthesia	14 (10)	18 (17)	32 (13)	0.5 [0.2, 1.1]
Seizure	12 (8)	14 (14)	26 (10)	0.6 [0.2, 1.4]
Scar/open wound	15 (10)	9 (9)	24 (10)	1.2 [0.5, 3.1]
Fever	4 (3)	14 (14)	18 (7)	0.2 [0.1, 0.6]*
Photophobia	1 (1)	1 (1)	2 (1)	0.7 [0.02, 26.1]
Other	24 (15)	25 (23)	49 (18)	0.6 [0.3, 1.2]

*Indicates a statistically significant difference.
Cases for which the information was unknown were not included.
OR = odds ratios, CI = confidence intervals.

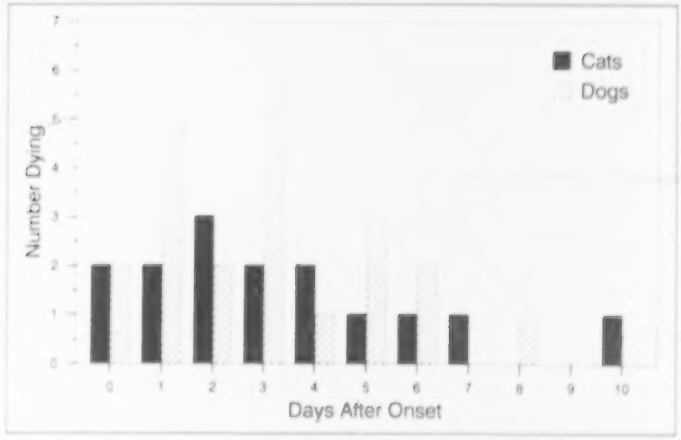

Figure 3—Interval from onset of illness to day of death in rabid cats and dogs allowed to die naturally.

Table 6—Rabies vaccine failures in rabid cats and dogs

Type of vaccine	Species	Route	Total doses	Age at vaccination	Period before onset*
PM-HKTC,† 1-yr	Cat	IM	1	3 mo	9 mo
SMBV,‡ 1-yr	Cat	IM	1	3.5 mo	4.5 mo
SMBV, 1-yr	Dog	IM	1	6 mo	1 mo

*Interval from date of vaccination to onset of rabies; †Pitman-Moore strain, hamster kidney tissue culture; ‡Suckling mouse brain vaccine.

failures (Table 6). All 3 animals were vaccinated when they were between 3 and 6 months old and had received only a single dose of vaccine in their lifetime. All vaccines associated with these failures were killed vaccines. The only vaccine implicated more than once was a suckling mouse brain vaccine (SMBV) produced by the same manufacturer but from 2 different lots. These 2 lots had National Institutes of Health relative potency values of 3.8 or 4.2 (2 tests were run on this lot) and 6.1 when released from the manufacturer. The lot number of the other vaccine was not available. All animals were vaccinated intramuscularly by licensed veterinarians.

Trends in characteristics of rabid dogs—Assuming the dog population is relatively constant, the incidence of reported rabid dogs decreased steadily from 1971 to 1988 (Table 7). Although rabid dogs in 1988 seemed to be younger than dogs in 1971 through 1973, this difference was not statistically significant ($\chi^2 = 5.26$, 2 df, $P = 0.07$). The proportion of owned dogs or dogs with aggressive behavior were similar among the 3 study periods. However, a higher proportion of rabid dogs reported in 1988 (14%) had a current or expired vaccination than those reported in 1971 through 1973 (9%; OR = 1.5, 95% CI = 0.8, 2.9). Although the difference was not statistically different, the likelihood of vaccine failures in 1971 through 1973 was several-fold higher than in 1988 (OR = 4.8, 95% CI = 0.7, 95.8).

Table 7—Comparison of rabies in dogs reported in 1971 through 1973, 1980 through 1983, and 1988

Characteristic	No. (%) of rabid dogs reported in: 1971-73	1980-83	1988
Average No. cases per year	210	178	119
Age (yr)			
< 1	77 (30)	*	40 (43)
1 to 3	111 (43)	*	31 (33)
> 3	70 (27)	*	23 (24)
Ownership status			
Owned	396 (87)	261 (80)	98 (90)
Stray	59 (13)	67 (20)	11 (10)
Aggression	79 (26)	113 (33)	32 (31)
Vaccination status			
Current	34 (8)	†	2 (2)
Expired	16 (3)	†	14 (12)
Never	331 (83)	246 (71)	76 (66)
Unknown	134 (25)	70 (20)	23 (20)
Vaccine failures	21 (4)	*	1 (<1)

*Data was not available. †Thirty dogs (9%) were previously vaccinated, but the proportion of dogs that were currently vaccinated was not available.

Discussion

Epidemiologic factors—The seasonality of rabies infection in cats and dogs in the United States seems to be related to seasonal increases in rabid wild animals. The peaks of rabid dogs reported during the spring and fall were consistent with reported increases in rabid skunks and raccoons during these periods.[10] Although the summertime increase in rabid cats was similar to the seasonal increase in rabid bats,[10] monoclonal antibody typing of rabies virus isolates from bats suggest that bats are rarely the source of infection for cats and other terrestrial animals.[12] In developing countries, seasonal increases in rabid dogs are mainly a result of increased mating activity.[13]

The large proportion of young rabid cats and dogs is probably related to either increased susceptibility of young animals to rabies infection[14] or

increased risk of exposures to rabies or both. Young animals are usually more active and presumably have more frequent contact with other animals than older animals. Information on the age distribution of the general cat and dog population was not available. Overrepresentation of young age groups among rabid animals has been reported in many developing countries.[15]

It is unclear why rabid dogs were predominantly male and rabid cats were predominantly female. This observation may simply be related to the gender distribution of cats and dogs in the general population (data were unavailable).

Although we found that rabid dogs were more likely than cats to have been pets, the ratio of pet cats and dogs to strays in the United States is unknown. The small percentage of reported rabid animals that were killed on roads probably is related to the fact that many state health departments do not test animals that are not associated with human or animal exposure.

Almost all rabid cats and dogs were reported from areas where rabies in wildlife species, especially skunks and raccoons, was enzootic.[10] Because almost a third of rabid dogs were observed in direct contact with a skunk within the 6-month period before illness, skunks are probably the major source of rabies for dogs in the United States. Dogs were more likely than cats to have had reported contact with wildlife, but this difference was probably attributable to the fact that dogs are generally better supervised than cats. A study of the mid-Atlantic raccoon epizootic during 1982 and 1983 revealed similar findings; 247 rabid raccoons had exposed dogs, compared with only 12 rabid raccoons that had exposed cats.[16] Therefore, animals that have been observed to have direct contact with wildlife species known to transmit rabies, such as skunks and raccoons, should be euthanatized if the animal does not have a current rabies vaccination unless area-specific surveillance data clearly indicate no rabies activity in the wildlife species.

Although most rabid cats and dogs were unrestrained at night or when outdoors, it is unknown how often cats and dogs in the general population are unrestrained. However, it is likely that these are risk factors for rabies. The finding that rabid cats were more likely to be unrestrained than rabid dogs can be attributed to the fact that cats are generally less likely to be restrained. A history of unexplained lameness or wounds was reported in a relatively large proportion of rabid cats and dogs and may have resulted from encounters with wild animals.

Most stray rabid cats and dogs were familiar to and had routine contact with people in the community. Many of these animals, therefore, may be more accurately described as community animals. The role of community animals in the transmission of rabies has been well described in developing countries.[17]

We found that, of approximately 900 people exposed to confirmed rabid cats or dogs in 1988, approximately 70% (630) had true exposures to rabies; therefore, 30% of postexposure prophylaxis regimens given as result of possible exposure to rabid cats and dogs may have been unnecessary. Therefore, only approximately 4% of the estimated 18,000 persons a year that receive postexposure prophylaxis do so as a result of true exposures to confirmed rabid cats and dogs. Helmick estimated that, from 1980 through 1981, 31% of people in the United States who received postexposure prophylaxis for exposures to cats or dogs were exposed to a confirmed rabid animal.[3]

If the cost of rabies postexposure prophylaxis is conservatively estimated at $514/patient (ie, $458 for the cost of the biologics and $56 for medical office fees),[18] the cost of administering postexposure prophylaxis to people exposed to all confirmed rabid cats and dogs in 1988 was approximately $462,000. Other substantial costs associated with these rabid animals include expenses involving the treatment of bite injuries, lost wages from work, and the destruction of other animals exposed to these rabid animals.

Rabies vaccination programs need to target cats as well as dogs. In 1988, cats became the most commonly reported rabid domestic animal for the first time.[10] Moreover, rabid cats are the cause of more human exposures to rabies than dogs. Rabid cats were more likely than dogs to have bitten people, probably because of the increased likelihood of aggressive behavior in rabid cats.

The study population, laboratory-confirmed rabid cats and dogs, was probably representative of all rabid cats and dogs that caused human or domestic animal exposure. However, because many state health departments tested only animals suspected of being rabid that were associated with human or animal exposures, rabies in animals that did not have contact with people or domestic animals was probably undercounted. Rabid animals that resulted in human or domestic animal exposures but escaped were also not represented in our study population.

Clinical findings—Although more rabid dogs than cats were taken to veterinarians, a higher proportion of rabid dogs were owned, and dog owners are more likely than cat owners to obtain veterinary care.[19] Veterinarians should be made more aware of the signs of rabies; most veterinarians who examined rabid cats and dogs in 1988 did not suspect rabies as their initial diagnosis. The 2 imported cases of rabies, one of which was imported into New Hampshire, illustrate the need to consider the possibility of this disease even in areas free of terrestrial animal rabies. The apparent relative difficulty of the clinical diagnosis of rabies may be largely attributable to the variability in clinical signs of disease and to the popular mis-

conception that both rabid cats and dogs are usually aggressive. The clinical behavior of rabid cats is likely to be aggressive and irritable. We found that 55% of naturally infected cats had aggressive behavior, compared with 69% of experimentally infected cats.[7] Rabid dogs, on the other hand, were more likely to have signs suggestive of a paralytic process such as lethargy, limb and jaw paralysis, and ataxia. The increased likelihood of aggressive behavior in rabid cats compared with dogs has been reported from other countries.[20,21] The proportion of dogs with aggressive behavior in our study (31%) was similar to that of dogs experimentally infected with rabies (37%).[7]

Although a large number of rabid cats and dogs were reported to be without clinical signs of rabies, we were not able to confirm any closely observed animal that was truly without clinical signs, and it is unlikely that infections without clinical signs develop in naturally infected cats and dogs in the United States. Although nonfatal rabies infections without clinical signs have been reported in naturally infected dogs from developing countries and in experimentally infected dogs,[22,23] this phenomenon is extremely rare.[24]

Our data support the recommended 10-day quarantine period for suspect rabid cats and dogs in the United States.[25] In our study, all rabid cats and dogs died within 10 days after onset of illness. The median length of clinical illness in naturally infected rabid cats and dogs (both 3 days) was similar to that reported for experimentally infected cats (5 days) and dogs (3 days).[6,7]

Vaccine failures and efficacy—The proportion of rabid cats or dogs that had a history of rabies vaccination was extremely low, but rabid cats were even less likely to have been vaccinated than dogs. This finding is probably related to the lower levels of veterinary care[19] and vaccination in cats than in dogs in the general population.

Although rabies vaccines in the United States for cats and dogs apparently have a low failure rate, it is unclear what proportion of vaccinated animals are actually exposed to rabid animals. Indeed, it is likely that vaccinated animals, which tend to be from urban areas and may be better supervised, are less likely to be exposed to rabies than unvaccinated animals.

The reasons for the 3 vaccine failures are unclear. However, each animal had been given only one dose of vaccine in its lifetime. Undoubtedly, the likelihood of an adequate immune response increases with subsequent vaccinations. The cases of rabies in animals that had been previously vaccinated, but whose vaccinations were not current, emphasizes the importance of adhering to revaccination schedules. All animals had been vaccinated when they were between 3 and 6 months old. Although the recommended minimum age for rabies vaccination for cats and dogs is 3 months,[8] dogs vaccinated at a later age seem to respond better than those vaccinated earlier. In one study, dogs vaccinated when they were between 9 and 12 weeks old had antibody titers several-fold higher than dogs vaccinated when they were between 6 and 9 weeks old.[26] Postponing the initial rabies vaccination to a later age, however, would probably decrease vaccination coverage because of the loss of opportunity to administer rabies vaccinations around the time of other routine immunizations, which are given before the animal is 6 months old. Because the median age of rabid cats and dogs is 1 year, animals that have not yet completed their primary series are at high risk for rabies. Therefore, if vaccine studies can demonstrate adequate seroconversion and protection by administering the primary series (2 vaccinations) before the animal is 6 months old, such a schedule may be more effective than administering the second vaccination 1 year after the initial vaccination. In addition, administering the primary series in conjunction with other routine immunizations may increase vaccination coverage.

Although 2 of the vaccines associated with failure were SMBV made by the same manufacturer, they were not related to the same production lot. The high relative potencies of the lots of SMBV at the production facility suggest that the vaccine lots were inherently immunogenic. We were unable to determine whether the vaccines were mishandled in the field.

The incidence of vaccine failures and the efficacy of rabies vaccines could not be accurately assessed because the number of cats and dogs vaccinated per year in the United States was not available. The most recent estimate of the cat and dog populations in the United States was 54,583,000 owned cats and 52,359,000 owned dogs in 1987.[19] In 1988, according to USDA records, 33,182,575 doses of rabies vaccine for all animals were produced and released for distribution by vaccine manufacturers in the United States.[27] Although the quantity of vaccine actually used, the quantity of vaccine exported to other countries, and the proportion of vaccine used by species were unknown, it is likely that most of the vaccine produced was used to vaccinate cats and dogs in the United States. Thus, the maximal proportion of owned cats and dogs vaccinated in 1988 would be approximately 31% (33,182,575/106,942,000). Although the proportion of vaccinated animals that were exposed to rabies was unknown, given the large number of doses produced and the few vaccine failures documented in 1988, the efficacy of rabies vaccines seems to be extremely high.

Trends in characteristics of rabid dogs—The reasons for the decrease in rabies in dogs in 1988 compared with earlier periods were unclear; however, the higher prevalence of previously vaccinated rabid dogs in 1988 suggests that vaccination

levels in dogs have increased. The lower rate of vaccine failures in 1988 compared with 1971 through 1973 suggests that rabies vaccines have improved or the risk of rabies in dogs has decreased, or both, during the intervening 15 years.

Our findings support the current recommendations for animal rabies control.[8,27] Current rabies control measures, especially vaccination of animals, have been highly effective in reducing the risk of rabies transmission from domestic animals in the United States. Given the various wildlife reservoirs of rabies in the United States and the fact that complete vaccination coverage in cats and dogs is virtually impossible to attain, it is unlikely that rabies in cats and dogs will be eliminated in this country. From a cost-benefit perspective, elimination of rabies in animals may not be desirable. Although rabies vaccines are highly effective, revaccination at recommended intervals are necessary. A positive history of vaccination does not preclude the possibility of rabies infection, especially if the animal has been vaccinated only once.

References

1. Human rabies—United States. *MMWR* 1979;28:313-316, 321.

2. CDC surveillance summaries, September 1988. *MMWR* 1988;37 (No. SS-4).

3. Helmick CG. The epidemiology of human rabies post exposure prophylaxis, 1980-1981. *JAMA* 1983;250:1990-1996.

4. Kappus KD. Canine rabies in the United States, 1971-1973: study of reported cases with reference to vaccination history. *Am J Epidemiol* 1976;103:242-249.

5. Crane SL, Baer GM. Reported canine and feline rabies in the United States between 1980 and 1983. *Rabies Information Exchange* 1986;13:38-43.

6. Vaughn JB, Gerhardt P, Paterson JCS. Excretion of street rabies virus in saliva of cats. *JAMA* 1965;184:705-708.

7. Vaughn JB, Gerhardt P, Newell KW. Excretion of street rabies virus in the saliva of dogs. *JAMA* 1965;193:363-368.

8. Compendium of animal rabies control, 1989. *MMWR* 1989;37:789-796.

9. 9 CFR §113.147.

10. CDC surveillance summaries, August 1989. *MMWR* 1989;38 (No. SS-1).

11. Imported dog and cat rabies—New Hampshire, California. *MMWR* 1988;37:559-560.

12. Smith JS, Baer GM. Epidemiology of rabies in the Americas. In: Campbell JB, Charlton KM, eds. Developments in veterinary virology—rabies. Boston: Kluwer Academic Publishers, 1988;267-299.

13. Malaga H, Lopez Nieto F, Castellanos E. Canine rabies seasonality. *Int J Epidemiol* 1979;8:243-245.

14. Tierkel ES. Canine rabies. In: Baer GM, ed. The natural history of rabies volume II. New York: Academic Press, 1975;123-137.

15. *Report of WHO consultation on dog ecology studies related to rabies control—Geneva, 22-23 February 1988*. Geneva: World Health Organization, 1988.

16. Jenkins SR, Winkler WG. Descriptive epidemiology from an epizootic of raccoon rabies in the middle Atlantic states—1982-1983. *Am J Epidemiol* 1987;126:429-437.

17. *Guidelines for dog rabies control*. Geneva: World Health Organization, Division of Communicable Diseases, Veterinary Public Health Unit, 1987.

18. Fishbein DB, Arcangeli S. Rabies prevention in primary care: a four-step approach. *Postgrad Med* 1987;82:83-91.

19. Trouman CM. Veterinary services market for companion animals: summary report. *J Am Vet Med Assoc* 1988;193:920-922.

20. Lobry M. Survey on current knowledge of rabies in cats. *Bull Epizoot Dis Afr* 1965;13:17-22.

21. Vaughn JB. Feline rabies. In: Baer GM, ed. The natural history of rabies volume II. New York: Academic Press, 1975;139-154.

22. Fekadu M. Asymptomatic non-fatal canine rabies (letter). *Lancet* 1975;1:569.

23. Fekadu M, Shaddock JH, Baer GM. Intermittent excretion of rabies virus in the saliva of a dog two and six months after it had recovered from experimental rabies. *Am J Trop Med Hyg* 1981;30:1113-1115.

24. Bell JF, Gonzalez MA, Diaz AM, et al. Survival rabies in dogs: experimental studies and results of a survey. *Am J Vet Res* 1971;32:2049-2058.

25. Rabies prevention—United States, 1984. *MMWR* 1984;33:393-402, 407-8.

26. Johnston RV, Newberne JW, York CJ, et al. Studies with Flury rabies vaccine in pups. *J Am Vet Med Assoc* 1957;130:61-63.

27. Veterinary Biologics notice no. 88. Hyattsville, Md: USDA, 1989.